

## REMARKS

Reconsideration of this application, as amended, is respectfully requested.

The amendments to claim 15 are supported in the Specification as originally filed, for example at paragraph [0042].

New claims 47-50 find support in the Specification as originally filed, for example at [0041], [0057], [0066]-[0068], [0077], and original claims 4, 5, 6, 8 and 9. No new matter is being added.

### **I. Claim 1 is Fully Supported in the Specification as Filed.**

The subject matter recited in claim 1, as amended, is fully supported in the specification as filed, for example:

An atomic layer deposition (ALD) process using starved reactions [0032], said ALD process comprising:

exposing a wafer to a starved dose of a first chemically reactive precursor [0034], said starved dose being less than one-half of a dose value required for a maximum saturated ALD growth rate for said first chemically reactive precursor [0039], wherein said first chemically reactive precursor is a soft saturating precursor characterized by an onset of a slow increase in ALD growth rate with further increases of precursor exposure dose [0036, 0039] and having a longer saturation time as compared to a second chemically reactive precursor to follow the first chemically reactive precursor [0036, 0039], and the exposure to the starved dose of the first chemically reactive precursor determines a value of a starved saturation ALD growth rate for a second chemically reactive precursor to follow the first chemically reactive precursor [0039, 0067]; and

exposing the wafer to a dose of the second chemically reactive precursor [0042, 0075], the dose of the second chemically reactive precursor selected for achieving starved saturation of the second chemically reactive precursor under variations in dose of

the second chemically reactive precursor [0067], said starved saturation characterized by an ALD growth rate of the second chemically reactive precursor being less than half of a maximum saturated ALD growth rate for the second precursor [0067].

wherein:

said starved dose of said first chemically reactive precursor and the dose of the second chemically reactive precursor are selected to obtain a maximum starved ALD process film deposition rate as measured in film thickness per unit time for the first and second chemically reactive precursors [0066, 0068, Fig. 9].

ALD growth rates of the first and second chemically reactive precursors are measured in film thickness per ALD process cycle [0040], and

said first and second chemically reactive precursors are delivered sequentially in time [0075] and in a manner so as to provide a substantially uniform film deposition on the wafer [0033-0034].

Accordingly, the rejections under 35 USC 112 should be removed.

## **2. Claim 1 and its Dependent Claims are Patentable over Park, Whether Considered Alone or in Combination with Matero.**

As amended, claim 1 is patentable over Park, US PGPUB 2002/0160585, whether considered alone or in combination with Matero (“Effect of water doses on the atomic layer deposition rate of oxide thin films”).

### **A. Park does not teach or suggest “an atomic layer deposition (ALD) process using starved reactions”.**

Claim 1 recites “an ALD process”. The hallmark of an ALD process is the saturation of the film deposition rate (i.e., a lack of growth of film thickness), even in the presence of increased exposure to the precursors. *See* George Declaration at para. 9, Matero at p. 1 (“an

excess of each precursor is supplied to saturate all the surface reactions. The saturation makes the film growth self-limiting . . .”), and Specification at [0006].

Park describes a process characterized as “ALD”, but which exhibits no saturation of the film deposition rate. *See* George Declaration at para 14. Specifically, at [0086]-[0087], Park reports a doubling of the film deposition rate (as measured by film thickness per cycle) for increasing exposure times of the TMA precursor.<sup>1</sup>

Because Park’s own report of the process being described fails to indicate saturation of the film deposition rate in the presence of increased exposure to the precursors, it cannot be an ALD process.

**B. Park does not teach or suggest “exposing a wafer starved dose of a first chemically reactive precursor”.**

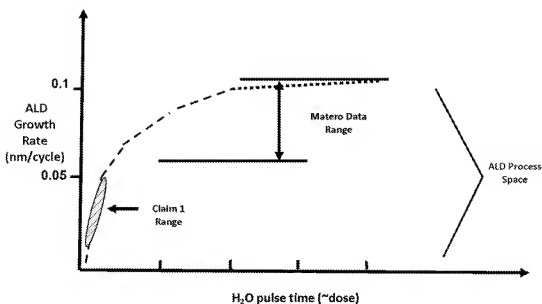
Claim 1 recites use of a “starved dose” of the first precursor. The starved dose is defined as a dose that is less than one-half the dose required for a *maximum saturated ALD growth rate* for the first precursor. Claim 1 also indicates that the first precursor is the “soft saturating” precursor in the ALD process. In an TMA-H<sub>2</sub>O process, it is the H<sub>2</sub>O that meets this definition of the first precursor. Specification at [0039].

It is well established that the maximum saturated ALD growth rate for the soft-saturating precursor in a TMA-H<sub>2</sub>O process (the process described by Park) is approximately 0.11 nm/cycle. *See, e.g.,* Matero at p.3, sec. 3.1 and Fig. 1 (reporting ALD growth rate as a function of H<sub>2</sub>O dose); *and see* George Declaration at para. 10. For a TMA-H<sub>2</sub>O process then, the language of claim 1 restricts the dose of the first precursor to one that is less than one-half the dose required for an ALD growth rate of approximately 0.11 nm. This can be illustrated graphically<sup>2</sup> as follows:

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<sup>1</sup> At [0086] Park states that a 0.2 nm film was obtained by exposing a substrate to TMA for “about 0.5 sec” and then to H<sub>2</sub>O for “about 1 sec” at 350 °C and 20 mTorr. Then, in [0087], Park states that by increasing the exposure to TMA to “about 2 sec” and continuing the exposure to H<sub>2</sub>O for “about 1 sec”, the resulting film thickness was increased to 0.4 nm. In other words, Park reports a doubling of the film deposition rate (as measured by film thickness per cycle) by quadrupling the exposure time of the substrate to the TMA precursor.

<sup>2</sup> In this illustration, pulse time is being used as a proxy for dose.

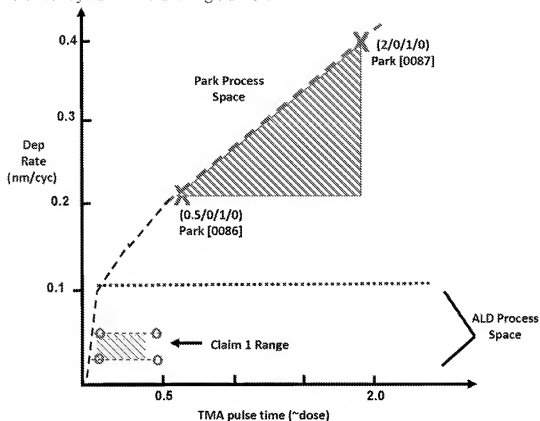


Park, on the other hand, reports cyclic deposition rates of 0.2 nm and 0.4 nm for an H<sub>2</sub>O pulse time of approximately 1 second. Park at [0086]-[0087]. Clearly, these are growth rates well in excess of even the maximum saturated ALD growth rate reported in the literature cited in the Office Action -- growth rates that, as illustrated in the above graph, cannot be achieved using a “starved” dose as defined in claim 1. Stated differently, Park’s own data, reporting ALD growth rates that are far in excess of that maximum saturated ALD growth rate, necessarily means that Park cannot be employing “starved” doses that are less than one-half the dose required for a maximum saturated ALD growth rate.

**C. Park does not teach or suggest a process in which exposure to a starved dose of a first precursor determines a value of a starved saturation ALD growth rate for a second precursor.**

Claim 1 specifies that exposure to the starved dose of the first precursor determines a value of a starved saturation ALD growth rate for the second precursor. As discussed above, in a TMA-H<sub>2</sub>O process, it is the H<sub>2</sub>O precursor that meets the other claim requirements for the first precursor. Therefore, the TMA must be the second precursor. According to claim 1, then, for TMA-H<sub>2</sub>O, the starved dose of the H<sub>2</sub>O determines a value of a starved saturation ALD growth rate for the TMA.

Park, however, does not report *any* saturation of the TMA growth rate. According to the data from [0086]-[0087] of Park, the cyclic deposition rate doubled in response to a four-fold increase in the TMA exposure time. This is not saturation, it is a time-dependent increase in growth rate. Again, a graphical depiction makes clear the differences between the process being described by Park and that being claimed:



In the above illustration, the “Claim 1 Range” is specified by further limitations in claim 1, which specify that the dose of the second precursor is selected for achieving starved saturation, which is characterized by an ALD growth rate less than half of the maximum saturated ALD growth rate. As indicated above, the accepted maximum saturated ALD growth rate for a TMA-H<sub>2</sub>O process is approximately 1.1 nm, hence, the claimed range can be plotted. The proposed claim 1 recites saturated deposition rates less than the maximum ALD saturated rates, and Park describes time-dependent deposition rates greater than the maximum ALD saturated rate.

#### **D. Matero does not cure the deficiencies of Park.**

Adding the teachings of Matero does not alter any of the above conclusions. Matero indicates that while film uniformity was substantially similar for both large and small H<sub>2</sub>O doses, the film growth rate was “substantially higher” for large H<sub>2</sub>O doses. *See* Matero, Abstract and Section 3.1, p.3. Combining such teachings with those of Park may, at best, allow one to arrive at a process where, like Park, there would be exposures to different doses of TMA and, like Matero, there would also be different doses of H<sub>2</sub>O, but is by no means clear what the resulting process would be, other than the process would not be that recited in claim 1 of the present application.

For example, neither Park nor Matero suggest a “starved dose” of the first (i.e., H<sub>2</sub>O) precursor. As indicated above, a starved dose is defined one that is less than one-half the dose required for a *maximum saturated ALD growth rate* for the first precursor and Matero reports only growth rates higher than one half the maximum ALD saturated rate (see, e.g., Figs 1 and 2 on p. 3 of Matero). As reflected in the above illustration, this is well outside the claimed process limitations.

Further, Matero does not indicate that exposure to a starved dose of the first precursor determines a value of a starved saturation ALD growth rate for the second precursor. Since Matero does not report any data concerning a starved dose of the first (i.e., H<sub>2</sub>O) precursor, it follows that there is no discussion of the effect of such a dose on the value of a starved saturation ALD growth rate for the second precursor.

Thus, combining the teachings of Park and Matero still does not yield the process recited in claim 1, as amended, and so claim 1, as amended, is patentable over these references.

If there are any additional fees associated with this communication, please charge  
Deposit Account No.: 19-3140.

Respectfully submitted,

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